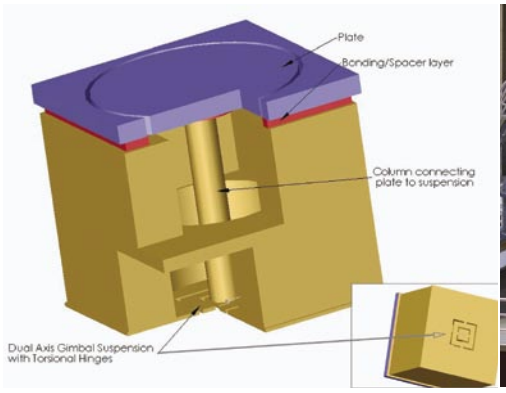
sensors and detectors

# Dual-axis, direct, fluid shear stress sensor offers nonintrusive measurement in a small package at low cost




NASA Goddard Space Flight Center (GSFC) invites companies to license this dual-axis, direct, fluid shear stress sensor, which quantitatively measures the shear force vector in a nonintrusive manner. The technology's unique combination of design elements enables the generation of high stress on the strain gauge from the low shear stress on the flow boundary wall, resulting in high spatial- and stress-resolution capability. Fabricated using microelectro-mechanical system (MEMS) technology, this new innovation offers micro size along with low-cost reproduction.

## Benefits

- **Nonintrusive**: Natural aerodynamic effects are not disrupted, and there is no impact on macroscopic flow parameters.
- **Micro size**: The fabrication technique uses MEMS technology for small size.
- **Low cost**: The fabrication technique enables production at low cost.
- **High spatial resolution**: The MEMS fabrication process and the device's three-dimensional design enable high packing density and contribute to high spatial resolution.
- **High precision**: Large numbers of sensors can be placed in arrays to build a more precise picture of fluid flow dynamics over a larger area of interest.
- **Versatile**: Dimensions of the shear force collecting plate can be tailored to resolutions (spatial, temporal and force) required for specific applications.

technology•opportunity

## Applications

This technology is suitable in the following applications but can be used in many other applications by varying the design parameters.

- **Aerodynamics**: Airfoil design, active flow control, etc.
- **Hydrodynamics**: Ships, submarines, etc.
- **Gas dynamics and flow**: Turbomachinery, pipelines, etc.
- **Polymer processing**: Polymer material characterization and online process control for molding and extrusion
- **Rheology**: Characterization of fundamental fluid properties and behavior
- **Other**: Nonintrusive flow sensors, fluid quality monitors

## Technology Details

Quantifying shear stress is important in a large number of situations involving fluid flow, including aerodynamics, hydrodynamics, turbomachinery, and polymer processing among others. The magnitude of the shear stress and the resolution required in various situations can span many orders from milliPascals to kiloPascals or more. The frequency response and spatial resolution needs also vary considerably. Many applications also require directional information and the ability to set up arrays of sensors to collect this information over large areas. This technology ideally meets those needs.

### *How it works*

This MEMS sensor directly measures shear stress in two axes. The device includes a force collecting plate that is in contact with the flow, a cantilever mounted to the plate, a gimbal structure for two axes of movement, and imbedded strain gauges to convert mechanical shear into an electrical signal.

The sensor is flush mounted with the flow surface to keep from disrupting the natural aerodynamic effects; and the gimbal structure, arm, and plate are designed such that the tilt of the plate caused by the shear stress does not impact the macroscopic flow parameters. All electrical leads and contacts are on the backside of the sensor, and the device is fabricated using a MEMS process, which contributes to its high spatial resolution.

### *Why it is better*

By using a MEMS fabrication technique, the improved design of these devices offers micro size and reproduction in large volumes at low cost. This creates the ability to use an array of sensors over a large area for the same or lower cost than one conventional "point" sensor.

Additionally, while custom-built devices can be obtained commercially that offer either direct or indirect measurement (i.e., inferring the stress from differential pressure measurements, heat transfer out of heated wires, or force exerted on small protruding walls) there are no devices that offer the small size, dense arrays, and direct vector measurements (x and y) that these devices produce. In fact, the smallest custom devices have a sensing area approximately the size of a quarter, while up to 100 of these sensors have been fabricated in a 5mm x 5mm square area.

The devices can withstand high vibration loads, and work is currently underway to fabricate devices that can withstand high temperatures (500ºC).

### *Patents*

NASA Goddard Space Flight Center is seeking patent protection for this technology.

### *Licensing and Partnering Opportunities*

This technology is part of NASA's Innovative Partnerships Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Dual-Axis Fluid Shear Stress Sensor (GSC-15431-1) for commercial applications.

## For More Information

If you are interested in more information or want to pursue transfer of this technology (GSC-15431-1), please contact:

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